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ITEM 5:* STATE OF THE ENVIRONMENT

UPDATED SCIENTIFIC REPORT ON THE ENVIRONMENTAL EFFECTS OF THE CONFLICT BETWEEN IRAQ AND KUWAIT

*(Second update of the UNEP report on the United Nations
Inter-Agency Plan of Action for the Region Covered by
the Regional Organization for the Protection of the
Marine Environment (ROPME))*

Report of the Executive Director

Introduction

1. Pursuant to UNEP Governing Council decision SS. II/8 of 3 August 1990 on the situation in the Middle East, UNEP took an initiative to intensify cooperation within the United Nations system for optimum use of the diverse capabilities of the system to respond rapidly to the environmental crisis resulting from the hostilities in the ROPME area (member States of ROPME: Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates. To that end, the United Nations Inter-agency Plan of Action was developed in cooperation with ROPME and a number of United Nations specialized agencies, and was adopted at the Second United Nations Inter-agency Consultation (Geneva, 15 March 1991). This was followed by the adoption of resolutions by the Governing Council of the United Nations Development Programme (UNDP) in June 1991, and by the Second Committee of the General Assembly at its forty-sixth session in November 1991. In addition, at its third special session the UNEP Governing Council adopted decision SS. III/3, part II on the state of the environment resulting from the conflict between Iraq and Kuwait.

2. The present report, prepared in accordance with Governing Council decisions 16/11 A and 16/17 summarizes the results of the inter-agency efforts of the United Nations in responding to the environmental crisis in the region. It provides an update of the environmental situation, based on the scientific results obtained through the surveys and assessments carried out under and in relation to the Inter-agency Plan of Action and briefly describes the United Nations' initiatives to mitigate the adverse effects of the conflict and rehabilitate the environment in the region.

* Refers to the number of the item on the Provisional Agenda (UNEP/GC.17/1).

II. UNITED NATIONS INTER-AGENCY PLAN OF ACTION

3. The United Nations agencies concerned with the various aspects of the environmental crisis in the ROPME region, led by UNEP and in cooperation with ROPME, developed the United Nations Inter-agency Plan of Action soon after the liberation of Kuwait. The main objectives of the Plan were:

- To assess the environmental consequences of the war on the marine and coastal areas, atmosphere and terrestrial ecosystems and the hazardous waste situation in the region; and
 - To propose a programme for the mitigation of the adverse effects, and for rehabilitation and protection of the environment affected by the conflict.
4. The specific objectives of the first (survey and assessment) phase of the Plan of Action were:
- To conduct a multidisciplinary initial survey and preliminary assessment of the marine and coastal environment, the atmospheric environment, the inland terrestrial environment and hazardous waste management in the war-impacted areas;
 - To identify priority areas at risk and resources threatened in these areas;
 - To formulate a proposal for the mitigation of the adverse effects, rehabilitation and protection of the environment in the area, to be submitted to the Governments of the region through ROPME for the necessary follow-up;
 - To develop, establish and operate a computerized data system (CDS) for storage, retrieval and processing of all data and information gathered through the Plan of Action; and
 - To provide relevant training to ROPME experts on CDS operations and data management.

5. Coinciding with both the Second United Nations Inter-agency Consultation (Geneva, 15 March 1991) and the Informal Ministerial Consultation, held in Nairobi (11 to 13 March 1991), UNEP's Executive Director established a Special Trust Fund devoted exclusively to financing the United Nations Inter-agency Plan of Action (except for the activities of the International Maritime Organization (IMO) which were to be funded by a special IMO Persian Gulf Oil Pollution Disaster Fund). A total of about \$2.67 million was received in the Trust Fund from the Governments of Japan, Norway, Netherlands, Norway and the Commission of the European Communities (CEC) as follows: Japan (general purpose) \$1.11 million; Norway (atmospheric components) \$1 million; the Netherlands (computerized data system) \$0.5 million, and the CEC (general purpose) ECU 50,000, i.e. about \$60,000.

6. The first phase of the United Nations Inter-agency Plan of Action started on 20 April 1991 and was completed in 90 days, i.e. on 21 July 1991. It involved initial surveys and a preliminary assessment of the environmental damage to the region in the aftermath of the conflict. The activities under the Plan of Action were coordinated by UNEP and ROPME and implemented by some 50 experts from 12 United Nations agencies and international organizations, including the International Maritime Organization (IMO), the World Health Organization (WHO), the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific Organization (Unesco), the United Nations Industrial Development Organization (UNIDO), the United Nations Centre for Human Settlements (UNCHS/Habitat), the International Atomic Energy Agency (IAEA),

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the Food and Agriculture Organization of the United Nations (FAO), the World Conservation Union (IUCN), the World Wide Fund for Nature (WWF) and ROPME, as well as about 20 institutions from within and outside the region. Each of the cooperating agencies was responsible for the implementation of the component(s) of the Plan of Action relevant to its specific mandate (see table below). However, all agencies worked in concert in order to ensure the maximum coherence of results and recommendations.

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Table
Activities of the United Nations Inter-agency Plan of Action
and the responsible Organizations/agencies

Areas/Activities	Responsibility
a) Coastal and marine environment - Oil pollution response and clean-up operations - Oil pollution assessment and monitoring, of water quality - Oceanographic observations and data support - Coastal/marine ecological assessment - Living marine resources - Coastal infrastructure - Remote sensing/database support	IMO IOC/IAEA ROPME/IOC IUCN/WWF/IOC IUCN/FAO/IOC UNCHS (Habitat) ROPME/UNEP
b) Atmosphere - Air quality/effects on human health - Air/sea exchange - Meteorology and long-range air pollution transport	WMO/WHO/IAEA IOC WMO
c) Terrestrial - Food, soil, agriculture - Terrestrial ecosystem/desertification - Food safety, drinking water - Shelter/welfare	FAO/IOC UNEP (Regional Office for West Asia) WHO UNCHS (Habitat)/WHO
d) - Hazardous waste management - Assessment of damage to industrial sector and risk of release of hazardous wastes - Industrial Safety	UNIDO/WHO/UNCHS UNEP (Industry and Environment Office)/UNIDO

II. STATE OF THE ENVIRONMENT

7. The preliminary results of the Plan of Action were published by UNEP in its report of 12 October 1991,¹ and were updated on 12 June 1992. The report of 12 October 1991 was submitted to and endorsed by the fourth extraordinary session of the Council of ROPME held in Kuwait on 16 and 17 October 1991. The initial findings of the Plan of Action are summarized below, together with some more recent observations after the capping of the last oil well fire on 6 November 1991, and the completion of a 100-day research cruise conducted in the ROPME sea area by the research vessel "Mount Mitchell" of the National Oceanic and Atmospheric Administration (NOAA) of the United States during the period February - June 1992.

A. Marine and coastal environment

1. Results of the initial surveys of the United Nations Inter-agency Plan of Action

8. Information gathered during the initial surveys indicated that, between January 19 and 28, 1991, an estimated 6-8 million barrels of oil were spilled into the ROPME sea area from two major sources: four sunken and leaking vessels, including Iraqi oil tankers, and leakage from the Mina Kuwaiti Al-Ahmadi Sea Island terminal mooring area and the Iraqi Mina Al-Bakr loading terminal. Additional sporadic discharges occurred from these and other sources through June 1991. Several hundred thousand barrels of oil seeped from damaged Kuwaiti and Iraqi oil facilities and several small Iraqi tankers sunk in the northern part of the sea area produced additional pollution through the spring and early summer of the region. Moreover, atmospheric fallout from Kuwait's damaged wells gradually introduced a considerable additional quantity of oil in the form of small oil droplets and oily soot.

9. As the main body of the oil slick moved south along the Saudi Arabian coast, winds repeatedly drove it onto shore and then back into the sea, leaving most of the northern shoreline of Saudi Arabia heavily contaminated, particularly in the area where the spill was blocked by Abu Ali Island and its causeway to the mainland. As the oil continued to move into the area, it backed up into the farthest recesses of the embayments north of Abu Ali Island. The most heavily affected areas were the lagoons, salt marches and bays located between Ras Al-Khafji on the north and Ras Abu Ali to the south.

10. The estimates of the extent of damage to the marine habitats in those areas varied. Early data indicated that at least 30,000 marine birds perished as a result of exposure to oil (excluding those trapped in oil pools formed in the Kuwaiti desert). Some reports showed that approximately 20 per cent of the mangroves on the eastern coast of Saudi Arabia have been oiled and about 50 per cent of the coral reefs have been affected. There was also some indication that hundreds of square kilometers of sea-grass beds (feeding grounds for dugongs and turtles) as well as tidal mud flats might have been inundated by oil. The Iranian coast north of Bandar Khomeyni was also

¹ Report on the United Nations Inter-agency Plan of Action for the ROPME Region - Phase I: Initial Surveys and Preliminary Assessment, UNEP, 12 October 1991

affected, but to a lesser extent, while the Iraqi coast was only slightly affected. The Kuwaiti coast suffered only relatively light damage, while the three coral reef islands off the Kuwaiti coast did not show any significant degree of ecological damage.

11. Based on observations during the initial surveys, the pollution by oil in the marine environment was not limited to oil spills. Fallout of soot and unburned oil products emitted from the burning oil wells formed slicks on the surface of the water, releasing polycyclic aromatic hydrocarbons (PAHs) and heavy-metal-laden soot particles into the water column. It was also observed that hundreds of small boats and dozens of military ships had been sunk in the area, many loaded with ordnance. The physical destruction of beaches by digging trenches, laying mines, barbed wire and other defence installations not only damaged the intertidal zone, but poses a great danger to human life as well as to turtles nesting on the islands. The destruction of sewage treatment plants in Kuwait resulted in the release of over 50,000m³/day of raw sewage into Kuwait Bay, threatening the intertidal ecosystem downgrading the quality of seawater used for desalination and polluting public beaches.

2. Results of the "Mount Mitchell" research cruise

12. Considering that the above results were essentially preliminary and were based primarily on the initial surveys, it was deemed necessary that the scale of the impact of the massive oil spill on the marine ecosystem, particularly on sensitive habitats, as well as on the fisheries (fish and shrimp) resources of the region as a whole would have to be determined by intensive monitoring and research. With that in mind, the intensive United Nations effort to assess the state of the marine environment culminated in the launching, in late February 1992, of a 100-day research cruise in the ROPME sea area by the fully equipped 231 foot research vessel "Mount Mitchell" of the NOAA of the United States of America, in cooperation with ROPME and Unesco/IOC. The expedition involved a broad range of investigations of the impact of the oil spill, including shoreline and nearshore studies along the most heavily impacted areas of the Saudi Arabian coastline, regional circulation and sediment studies, studies of coral reefs, and investigations of seafood quality. The investigations were carried out at a large number of stations covering almost the entire ROPME sea area as shown in the figure below. The results of the international expedition will provide the scientific basis for the rehabilitation of the marine and coastal environment in the ROPME sea area. In addition, the information gained should be of considerable value, not only for the present spill, but also for dealing with future large spills throughout the world. The main findings and conclusions drawn to date on the basis of these results are summarized in paragraphs 13-27 below:

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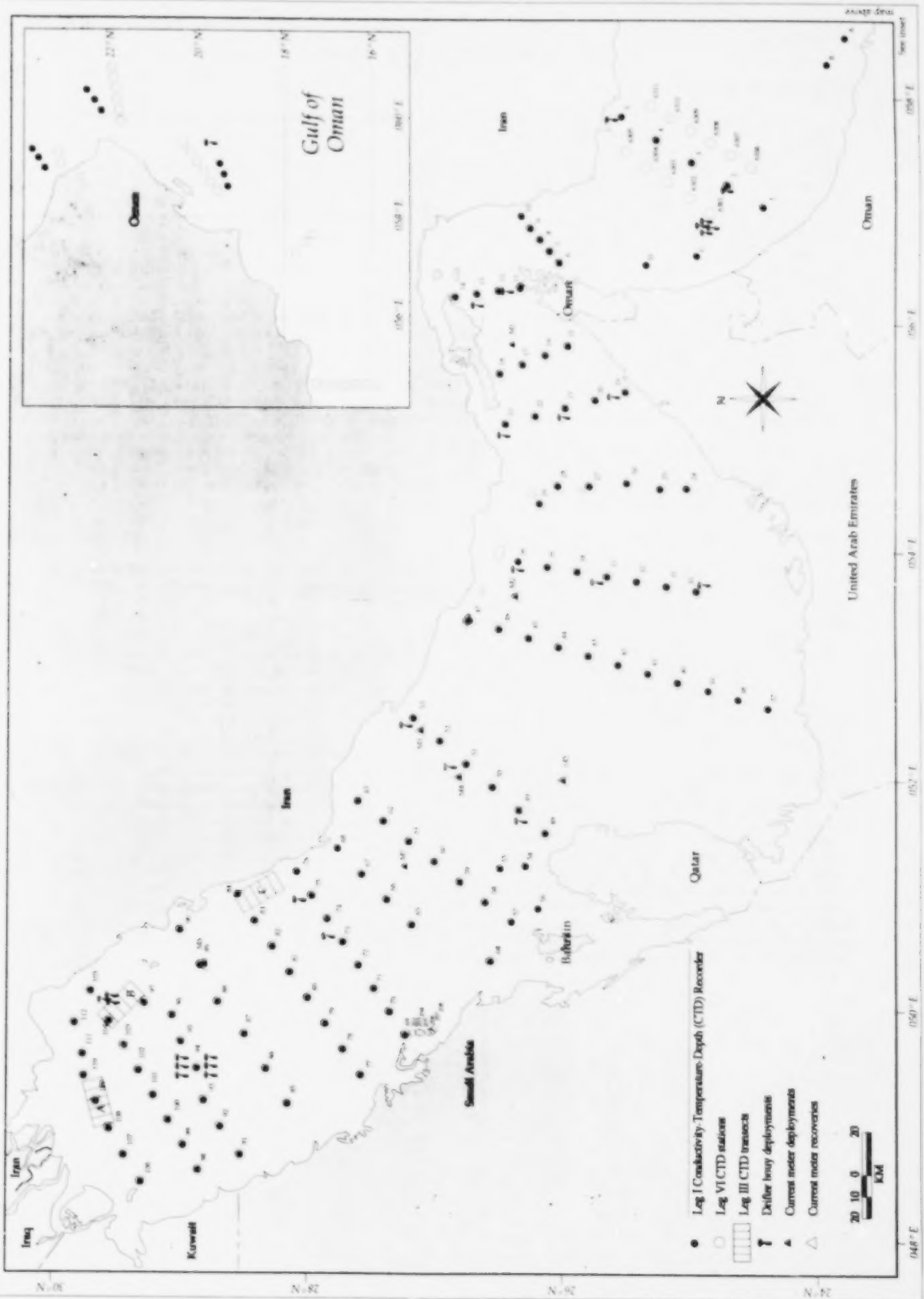


Figure: Coverage and stations of the "Mount Mitchell" research cruise in the ROPME sea area (February-June 1992)

3. Impacts of oil pollution

Effects on water

13. Evaporation studies undertaken during the cruise indicated that winter evaporation in the ROPME sea area can be double the summer amount: hence was the rapid evaporation of the oil spill, as it occurred under winter conditions. In the water column, decomposition of the oil was found to be relatively fast. The result is that very low concentrations (no higher than 4 micrograms per liter) of the oil were present in the samples collected from the water column. In contrast, concentrations of the breakdown products (oxidation products) of oil were found to be about ten times higher than concentrations of their parent hydrocarbons. However, with distance concentration dropped rapidly, with the most heavily oiled zones at the heads of the bays.

14. Subsurface oil was present in many areas in a variety of habitats. Oil-saturated intertidal waters were common in many of the intertidal habitats. Distribution of total hydrocarbons in water showed a different pattern, with Ras Tanajib being the highest (12.1 mg per litre), followed by Ras Al-Mishab, Ras Al-Khafji, Ras Al-Zoor, Manifah, Mardoumah, Ras Abu Ali (coastal), and Jurayd Island. Samples collected off Jana Island, Juaymah and Ras Abu Ali (deep sea) were found to be free of hydrocarbon concentrations.

15. The results of the analyses of trace metals in water samples, based on historical data from within and outside the region, do not indicate that the trace metal content of the water has increased as a consequence of the oil spill during the recent hostilities in the region.

Effects on sediments:

16. The subtidal sediments in the near offshore areas of the ROPME sea area, from Kuwait to Qatar, were found to contain relatively low and uniform concentrations of polynuclear aromatic hydrocarbons. The oil components cause contamination of the subtidal sediments in sheltered muddy bays were found, with the highest concentrations (500 - 900 parts per million total hydrocarbons) occurring in the heads of Dawhat al Musallimiyah and Dawhat ad Dafi. In the areas investigated there was no evidence of large-scale sinking of oil. Following diverse observations at over 150 locations, oil was observed at three sites, all of which were channel bottoms where tarballs were accumulating. During sediment core handling, only a very few samples had a petroleum odour or showed visible oiling of the surface sediments. It is believed that the contamination of the bottom sediments probably occurred through the deposit of oiled sediments eroded from the intertidal zone. Deep burial by sediment deposition was not common, but penetration measured in tens of centimetres was enhanced by penetration of oil into burrows (especially the numerous intertidal crab burrows) and by the presence of bubble sand and evaporite crystals in the sediment. Sheltered sand beaches, resulting from wind-blown coarse sand being added to the beach zone, present a special problem because of deep penetration of oil into the coarse sand (up to 50+ cm) and slow erosion rates. In contrast, many of the exposed sand beaches and intertidal sand flats showed significant erosion of the original oiled sediment (estimated 50-70 per cent removal in some areas). Some of this material was being transported into the subtidal region in the form of tarballs and finer oil/sediment particles.

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17. High-performance liquid chromatography screening was carried out on more than 100 sediment samples to evaluate the extent and magnitude of oil contamination within the heavily impacted area between Abu Ali and Tanajib. A number of sediments showed elevated concentrations of aromatic compounds. Oiled sand clumps were observed floating on the water surface, thought to be caused by air bubbles becoming attached to sand during low tide, allowing the clumps to float off with the rising tide. Eventually, wave action will break up the bubbles and the sand will sink, providing a mechanism for deposition of contaminated coarse sediment in otherwise sheltered, muddy environments.

18. In contrast to the visual observations, preliminary chemical analysis (fluorescence), using a method for comparison of relative concentrations among the sample set, provided some indication of wide-spread, low-level oil contamination of the fine-grained sediments. The results showed that the highest oil concentrations in subtidal sediments occurred within the top 5 cm, with concentrations usually dropping off by a factor of 5 to 10 between the 0-5 cm and the 5-10cm intervals. At depths below 10 cm, concentrations were always at background levels. Highest levels of contamination were found in the muddy sediments accumulating in the dredged channels at the head of Dawhat ad Dafi and relatively high concentrations were also measured in the sheltered interior bays of Dawhat al Musallimiyah. Intermediate levels of contamination were found in the fine-grained sediments collected from mid-bay, from in the lee of sand shoals, and from rocky platforms. The lowest levels were found in the coarse-grained sand from the outer coast transects, at the bottom of channels, and from the thin sediment veneer on the mid-bay shoals.

Effects on the shoreline

19. At the time of the cruise, about one year since the spill during the conflict between Iraq and Kuwait, much of the residual oil exhibited considerable weathering, compared to the oil which was initially stranded on the shoreline. However, there were areas of heavy oil which remained relatively fresh and continued to be released as sheens. Oiled areas in exposed habitats were generally in an advanced state of weathering, and were more weathered than in moderately and sheltered habitats. As indicated by detailed chemical analysis, using various techniques to fingerprint the oil, most areas sampled in Dawhat al Musallimiyah, Dawhat ad Dafi, and Tanajib were impacted by oil from the spill. However, there were areas, such as the extensive pavement formed on Abu Ali Island and isolated sites in Dawhat ad Dafi, that were shown to be contaminated by oil from previous spills.

Effects on coral reefs

20. Observations taken before and during the "Mount Mitchell" cruise were unable to reveal any demonstrable, direct effects of the 1991 oil release on the coral reefs in most of the ROPME sea area. This does not indicate that oil spills have no potential for causing damage to coral reefs. The disturbance caused by an oil spill and other forces may have increased the susceptibility of real organisms to natural stress.

21. Generally, coral reefs examined throughout much of the "Mount Mitchell" cruise appeared to be in good condition. However, the corals of the three reefs examined in Kuwait showed signs of stress. At Qita't Urayfijan, Taylor Rock and Kubbar Island, numerous corals were bleached or had suffered recent partial or total mortality. At the first two sites, several species of corals (from various families) were affected, while at Kubbar Island large sections

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of bleached tabular *Acropora* species were particularly conspicuous. It must be realized that the survey team visited only an arbitrarily selected portion of each reef and a limited number of reefs at each station. However, it is considered unlikely that the study of other, arbitrarily selected regions of these reefs would have led to substantially different observations.

22. In light of the observations in paragraph 21 above, it is to be kept in mind in the past the reefs of Kuwait, including Kubbar Island reefs have been observed to show bleaching and resultant mortality following extreme periods of cold weather and reduced sea-surface temperatures. It is known that during the winter of 1991-92 seawater temperatures were approximately 4.5°C lower than normal. When the corals of Kuwait were visited in November 1991, no signs of stress on the corals of Kubbar Island were observed. But, apparently, the cold waters off Kuwait during the winter of 1991-92, high precipitation in the adjacent riparian watershed, and other climatological phenomena may have contributed to the observed condition of those corals. However, one cannot rule out the possibility that the corals were affected by the environmental damage that resulted from the conflict, including the adjacent oil release, smoke clouds, and sewage and pollutant releases. It is difficult to single out the effects of these and other sources of stress on the corals. In addition, the many sources of natural and anthropogenic stress to which these reefs were exposed may have important additive or synergistic effects. Subsequent analysis of the coral skeleton showed definite and consistent signs of stress in the massive coral *Platygyra daedalea* at Qita't Urayfijan, as well as in some colonies at the reef at Khafji in northern Saudi Arabia.

23. Further to the south of Khafji the corals at surveyed sites did not show any of the stress described in paragraph 22 above. Similarly, other parts of the coral reef community, including fishes, macroalgae and invertebrates, showed no signs of unusual stress in May 1992. Another individual observation indicated that spawning of *Acropora* species found on reefs in the path of the oil was not impaired during 1991 or 1992. It is possible that surface oil may have affected the reproductive products of corals and other reef organisms found at the sea surface after spawning. Scientists working in Saudi Arabia reported significant mortalities of reef corals during early 1992, however these were attributable to natural stresses. In general, reefs in nearshore areas throughout the region live under greater stress than those of the offshore islands. Based on previous studies, it is believed that oil spills that strike shallow subtidal reefs at extremely low tides, or which coincide with the mass spawning of corals and other coral reef organisms, may pose a much greater risk to coral reef organisms.

Effects on seagrass and algal mats

24. Three species of seagrass were examined (*Halodule unireivo*, *Holoplaeta ovalis* and *Holophila stipalacea*). Leaf tissues were incubated for 12-18 hours in the seawater-soluble fraction of Kuwait crude oil at a strength of 1 per cent (volume/volume); 170 different types of crude oil solution were used. There were no significant effects on the respiration or photosynthesis of the seagrass. These results, coupled with the field observations during the "Mount Mitchell" cruise, suggest that the oil had little effect on the subtidal seagrasses of the northern part of the ROPME sea area. In general, the seagrass systems studied appear to be thriving.

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25. Concerning algal mats, damage was concentrated on the upper intertidal zone. In general, extensive damage was exclusive to algal mats in unprotected environments. Recovery from oil pollution was detected in Tanajib and the Abu Ali area.

Effects on Fisheries

26. The biological studies undertaken during the "Mount Mitchell" cruise were concentrated in the western ROPME sea area in order to be able to relate impacts of the 1991 oil releases to those areas and habitats where oil release occurred. In view of this limited geographic coverage, and because of the limited number of fish and plankton samples collected, it is still premature to establish geographic trends along the western margin of the area. There were few unequivocal effects of oil pollution that were attributable solely to the 1991 releases. However, in some of the studies there were tantalizing suggestions that localized pollution did exist. Natural variability between the sampling locations needs to be better understood, especially with regard to the plankton, so as to separate natural population distributions from changes caused by pollution or other stresses. In addition, the question of whether there has been a general decline in the region's fish and shrimp stocks is yet to be addressed.

27. A definitive understanding of possible risks to human health from polynuclear aromatic hydrocarbons associated with fishery products requires a considerable amount of additional information on consumption patterns, food preparation techniques, dose-responses and hydrocarbon distribution in the products. However, current thinking in the ROPME sea area and experience from oil pollution studies in other parts of the world suggest that commercially caught fishery products do not constitute a health hazard to the average consumer.

B. Atmospheric pollution, including long-term effects on human health

28. The studies and surveys on atmospheric pollution and its impact on human health carried out by WMO and WHO under the United Nations Inter-agency Plan of Action continued beyond the 90-day first phase of the Plan of Action (20 April - 21 July 1991) in order to allow for further analysis of the results, particularly with respect to a possible impact on human health.

29. At a meeting of experts to assess the atmospheric effects of the Kuwait oil fires, organized by WMO in cooperation with UNEP (Geneva, 25-29 May 1992), the results of extensive aerial reconnaissance surveys of the fire plumes, were analysed. The surveys had been carried out by teams of investigators, from different countries. At the same time, the experts analysed meteorological and air pollution measurements in and around the source region, with a view to obtaining a better understanding of the atmospheric effects of the oil well fires. Further insights into plume behaviour and its long-range transport were provided by modelling. The major findings of the above expert meeting² concerning atmospheric pollution from Kuwait oil fires and its consequences are summarized in paragraph 30-41 below.

² Report of the Second WMO Meeting of Experts to Assess the Response to and Atmospheric Effects of the Kuwait Oil Fires (Called in collaboration with UNEP). WMO, Global Atmosphere Watch No. 81, Ref. WMO/TD-No.512, 1992.

Effects on global climate

30. The base of the smoke plume was generally at a height of between 0.5 and 2 km and its summit was never detected above 6 km. The smoke particles coagulated as they were transported downwind. They became hydrophilic as a result of being coated with sulphate, whereby substantially increasing the efficiency of their removal by clouds and rain. Because of its relatively low altitude and short residence time, due to capture by water vapour, the smoke did not have any attributable effect on the weather or climate outside the Persian Gulf region. There has also been no demonstrable influence on the Indian monsoon.

31. During the period the fires burned, the total emissions of carbon dioxide are estimated to be 3×10^8 tonnes, which is about 1.5 per cent of the world-wide annual emissions from fossil fuel and biomass burning. The carbon dioxide and nitrous oxide emissions steadily diminished as the burning wells were brought under control. The calculated effect of such carbon dioxide emissions on global warming is so small that it will be immeasurable.

Effects on regional and local weather

32. The smoke plume widths ranged from 15 to 150 km for distances of 0 to 1,000 km from the fires, reducing ground-level sunlight, visibility, and the temperature beneath the plume. Although local and regional temperatures and solar flux were reduced under the plume, there is no evidence that regional weather was consistently affected.

Plume concentrations and chemistry

33. Within the composite smoke plume, peak concentrations of particulate mass exceeded recognized occupational health standards. Sulphur dioxide occasionally exceeded the standards stipulated. The peak concentrations of ozone, nitrogen oxides, and carbon monoxide were below stipulated standards. Consequently, because the plume remained above the ground for most of the time, these conditions were experienced for short periods mainly by those who flew through the plume. There was no impact on the region's population.

34. The plume was not photochemically active until it had travelled over 200 km. Inside the plume 1,000 km downwind of Kuwait, the ozone concentration occasionally exceeded the United States National Ambient Air Quality Standard (NAAQS) of 120 ppb. However, there is no indication of regional oxidant episodes resulting from the fires. Regional ozone concentrations were not substantially elevated and there was no impact on the region's population.

Ground-level concentrations and their relation to human health

35. The concentrations of total suspended particulates (TSP) and particulate matter (PM-10) often exceeded the local and other recognized standards in the region. These concentrations were often higher in Daharan than in Kuwait City. However, occurrences of high concentrations of particulate matter have been common in the region, making it difficult to determine the contribution from the oil well fires without chemical analysis. Initially, there was concern that the increased TSP and PM-10 concentrations would severely impact on health, but levels were not high enough to cause observed acute health effects. Active irritating agents were significantly absent from the particles.

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36. In Kuwait and Saudi Arabia the ground-level concentrations of nitrogen dioxide, nitrogen oxides, carbon monoxide, hydrogen sulphide and ozone did not exceed the local and recognized standards. There were instances in which sulphur dioxide concentrations exceed the local standards. Initially, there was concern that pollutant gases from the fires would have acute effects on health. However, generally the population was not exposed to persistently high concentrations of gases. Ground-level concentrations were comparable to recognized air quality standards designed to protect public health and welfare, and reports of widespread and acute effects on health were not substantiated.

37. In-plume and (ground-level) ambient air concentrations of polycyclic aromatic hydrocarbons (PAHs) and metals such as nickel, chromium, vanadium, and lead from the fires were usually below 1 ug/m^3 , i.e. comparable to those in urban-industrial areas in Japan, Western Europe and the United States.

38. There is no indication that acidic precipitation occurred on the Arabian Peninsula due to the fires; however, it may have occurred in Iran. There is no firm evidence of an influence on precipitation acidity outside the ROPME region.

39. Soot and oil mist covered the soil surface and vegetation in large areas, with the soot-affected area extending into Saudi Arabia. Most of the native vegetation in the soot-affected areas was adversely affected. The annual flora failed to set seed. Only some perennial vegetation with food-reserve in the roots survived the summer of 1991. The long-term impacts of soot and oil deposition are unclear, but there are indications that vegetation is being re-established effectively. However, there might be a change in the distribution of species.

Immediate and long-term effects on human health

40. Air pollution resulting from the burning oil wells in Kuwait represented a potential hazard to human health. However, the last of the 613 burning wells in Kuwait, which were the main source of concern with regard to air pollution and risk to human health, was put out in record time on 6 November 1991. Consequently, the atmospheric conditions and air quality in Kuwait and the adjacent areas improved rapidly and significantly. This considerably reduced the risk to human health.

41. In addition, in view of the fact that the smoke plume was, on average confined to heights between 500 m and 4 km above ground level (only on one occasion was it detected at 6 km), and that the plume rarely touched the ground, the immediate hazard to human health was drastically reduced. Nonetheless, possible long-term effects are still uncertain and, therefore, long-term, detailed studies of the pollutants themselves and of the exposed population are required.

C. Terrestrial ecosystem including hazardous wastes

42. Initial surveys of the terrestrial ecosystems in the areas affected by the conflict were carried out under the United Nations Inter-agency Plan of Action during August-September 1991 by UNEP (Terrestrial Ecosystems Branch (Soil Unit) and the Regional Office for West Asia - ROWA). Three

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comprehensive reports on the results of the survey and assessment mission in Iraq, Kuwait and Saudi Arabia were published by UNEP/Terrestrial Ecosystems Branch (Soils)/ROWA³. The main findings of these surveys are set out in paragraph 43-45 below.

Iraq

43. The shelling and bombing from air-raids and rockets led to the complete destruction of the infrastructure, including power stations, water installations, oil refineries and oil storage depots as well as six oil wells. The consequences were:

(a) Drainage water pumps were put out of action, resulting in accumulation of drainage water, raising the water table and increasing soil salinity in vast agricultural areas;

(b) Destruction of fertilizer plants and other factories left the country without these important agricultural inputs;

(c) Toxic chemicals were spilled into soil and into running streams when several industrial plants were bombed;

(d) Both crops and livestock were very adversely affected. As no pesticides were available, the main crop, wheat, was attacked by pests, which reduced total production by about 40 per cent. Livestock was devastated by serious epidemics, e.g. rinderpest. Sheep herds were either subjected to overslaughtering or taken to neighbouring countries by fleeing pastoralists seeking higher prices. The rangelands of Iraq, especially of the west desert, have been drastically affected and degraded.

Kuwait

44. Serious damage to the terrestrial ecosystem was observed in Kuwait. The consequences of this damage were:

(a) The soot and oil mist coming out of the burning oil wells have covered the soil surface and vegetation over large areas. The area affected by soot was observed in the Burgan oilfield and along the Ahmadi - Wafra road towards the south;

(b) Most of the native vegetation in the areas affected by soot has been adversely affected. The annual flora failed to set seeds. Only some perennial vegetation with food-reserve in the roots was alive, but all other perennial vegetation was either killed or severely damaged;

(c) Oil escaping from exploded wells accumulated to form oil lakes extending over large areas of the desert, in some cases with depths of up to 1 meter or more. Oil penetrated into the soil below. The depth of oil penetration varies from a few centimetres to one metre, depending upon the nature of the soil and depth of oil at the collection site;

³ A Rapid Assessment of the Impacts of the Iraq-Kuwait Conflict on Terrestrial Ecosystems. Part I: Iraq; Part II: Kuwait; Part III: Saudi Arabia. UNEP/Terrestrial Ecosystems Branch (Soils)/ Regional Office for West Asia, Bahrain, September 1991.

(d) The sandy oil belt around Kuwait Bay and along the coast has been disturbed by military activities. The affected soils have been further exposed to wind erosion. Pulverization of the surface soil by off-road military vehicles in other areas destabilized the soil, increasing its vulnerability to wind erosion;

(e) Disruption of irrigation in afforested areas in the north of Kuwait City caused severe damage to young plants.

Saudi Arabia

45. The area affected by soot lay south of the Saudi Arabia-Kuwait border and to the east of a line passing through Nairyah down to Al-Dammam and parallel to the Persian Gulf coast. The following are the main observations on the consequences of the damage caused by the war:

(a) The limited oil spills on the land have an influence on the halophytes growing in the salty areas (sebkhas);

(b) The sandy soil belt along the coast has been disturbed by military activities;

(c) Vehicle movements have pulverized surface soils, exposing them to erosion from both wind and water. In many sites, the soils have been extensively compacted;

(d) The adverse effects described earlier have taken appreciable areas out of grazing, thus increasing the gravity of overgrazing which, in addition to severe soil disturbance, has caused the disappearance of perennial plants;

(e) Death of *Hammada elegans* and other species are dying in the Al-Khafji area due to dense soot fallout and, possibly, oil mist. The death rate among the vegetation decreases as one proceeds away (southward) from the source;

(f) Vegetation seed productivity has been reduced by the soot.

46. The above findings of the initial surveys conducted under the United Nations Inter-agency Plan of Action were confirmed by a independent study carried out by the Environmental Protection Department (EPD) of the Ministry of Public Health of Kuwait. The EPD study showed that from 76 gushing oil wells, over 100 oil pools were formed covering a total area of about 16 km². The areas between the pools were also soaked by oil. The depth of the oil pools varied according to the local topography of the areas and was generally between 30-50 cm, with a few as deep as one metre. Estimates of the quantity of oil accumulated in these pools range between 25 and 50 million barrels.

47. The air immediately above the oil pools contained a much higher level of methane and non-methane hydrocarbons, detected by the air quality monitoring system run by the EPD. Of particular concern, especially with respect to health impacts, was the level of toxic chemicals and PAHs. However, investigations showed that most PAHs in the air particulate samples in Kuwait and Saudi Arabia were, in general, below detectable levels.

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48. Deep and surface soil samples were collected from within and outside the oilfields by the EDP. The samples were analysed to determine the level of total removable organic matter, petroleum hydrocarbons and chrysene equivalents. As expected, much higher levels were detected in the surface samples collected from the oilfields, with much lower levels in the deep samples.

49. With respect to hazardous wastes, the initial surveys carried out by UNIDO indicated that the risk to the environment and human health will remain fairly acute until plans are designed and implemented to assess and clean up the disposal sites, both in Kuwait and Iraq, each according to its particular characteristics.

50. Some media reports (January 1993) have indicated that there is the possibility that depleted uranium shells (penetrators) might have been used during the conflict between Iraq and Kuwait, posing a serious threat to human health in these countries. The reports have not yet been confirmed by independent sources. However, in view of the danger such shells may present to human health and to the environment in general, the matter is now being investigated by UNEP in cooperation with WHO, IAEA and the Governments concerned, in order to validate the media reports and, if appropriate, advise on suitable measures.

III. SOCIO-ECONOMIC ASPECTS

51. The conflict between Iraq and Kuwait, the associated hostilities and the resulting environmental damage have had serious socio-economic impacts on the countries of the region and beyond. The implications for the countries affected range from loss of job opportunities, particularly in the fisheries, agricultural and industrial sectors, to threat to human life from the presence of unexploded ordnance and sea and land-mines.

52. UNDP, in decision 91/21 of the 38th session of its Governing Council, requested that a funding strategy meeting be convened to consider a draft proposal for the socio-economic and environmental recovery of countries affected by the conflict between Iraq and Kuwait, with a view to establishing a funding strategy. In that connection, UNEP prepared a Consolidated Rehabilitation Programme, containing a proposed programme for the environmental rehabilitation of the region, the implementation of which would assist in the alleviation of the above socio-economic problems.

IV. UNITED NATIONS FOLLOW-UP INITIATIVES

53. While the United Nations inter-agency efforts were being undertaken at the technical level, further attention was being paid to the political and financial aspects of the environmental crisis. In that context, and following a request from the Government of Kuwait, a first visit to Kuwait was undertaken by the personal representative of the United Nations Secretary-General in early October 1991.

54. The Consolidated Rehabilitation Programme for the environment of the ROPME region, as well as a priority action programme, prepared by UNEP in cooperation with ROPME, incorporated costed and targeted project proposals covering the three environmental components, technical cooperation aspects, and the needs of the countries of the region with respect to oil clean-up, recovery and restoration. The Rehabilitation Programme was presented by UNEP

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to a funding strategy meeting organized by UNDP on 16 December 1991. At that meeting, the urgent need for rehabilitation of the environment in the region was brought to the attention of some 70 Member States of the United Nations, including major potential donors.

55. The issue of environmental rehabilitation was later brought up at the third special session of the Governing Council of UNEP, where it was also made clear that dealing with such an environmental catastrophe went beyond the capabilities of the countries of the region, and thus required strengthened international cooperation. Furthermore, and in order to keep the environmental crisis at the forefront of the international political arena, the Secretary-General requested his special representative to visit Kuwait during March 1992, and later the other countries of the region, to reassess the situation after the capping of the burning oil wells. The visit to Kuwait was carried out from 29 to 31 March 1992, during which the Secretary-General's special representative, accompanied by a senior staff member of UNEP, held talks at the highest possible level. The Government was assured of the continued support of the United Nations and all its organizations in finding adequate measures to redress the environmental damage in Kuwait and the region.

56. Recognizing that the task of environmental rehabilitation is challenging and that the financial resources needed are very large, during the short visit, the Secretary-General's representative discussed various options for rehabilitation strategies and funding possibilities. The outcome of the visit has been brought to the attention of the Secretary-General and the Executive Director of UNEP, in order for an acceptable strategy to be formulated and applied as soon as adequate resources become available.

57. In addition to mitigating the adverse effects, rehabilitating the environment and building up the national response capabilities, there is also an obvious need to develop an effective international mechanism to guide and coordinate the response to future large-scale environmental crises. Such a response should be based on a predetermined procedure to initiate immediate action and on the criteria to be applied to trigger an international response. Experience from dealing with the conflict between Iraq and Kuwait, with all the complexity of its environmental consequences, showed that the United Nations agencies can work together effectively if the objectives of the joint action are laid out, the distribution of responsibilities is clearly defined, and a strategy for coordination, communication and data management is developed and implemented from the outset.

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